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Imam El-Sawaf
Lecturer at Mechanical Power Engineering Department., Faculty of Engineering., Suez Canal University., Port-Said., Egypt.

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LEADING EDGE WEAR AND SLIDING WEAR OF THE VANES OF A CENTRIFUGAL MODEL-DREDGE-PUMP

Dr.Eng.Imam El-Sawaf*

* *Suez Canal University, Faculty of Engineering, Port-Said, Egypt.*

بلى الحافة المتقدمة وبلى الانزلاق لريش نموذج مضخة طاردة مركزية لكراكـــه

الخلاصة :

ان حدوث النحات فى الطلمبات وخطوط الانابيب الناقله للطين السائل هو امر حتمى، وبالرغم من اهميته فان آلية حدوثه ليست مفهومه حتى الآن. كما ان العائق الاساسى للدراسة التصنيفية تنبع من ان النحات هو عملية بطيئه دائما، مما يجعل التجارب طويلة الأجل مطلوبه وتلك بدورها تجعل البحث مكلفا جدا.

تم فى هذا البحث انشاء طريقة قياس لتصنيف بلى النحات لريش نموذج مضخه طاردة مركزية، وامكن بذلك تمييز بلى الحافه المتقدمة وبلى الانزلاق للريش باستخدام قوالب صممت خصيصا للحافة المتقدمة. كما ان استخدام نموذج المضخه الطاردة المركزية ذو الدفاعه القابلة للخلع مكننا من قياس بلى الريش بصفة منفردة لكل من الحافة المتقدمة والسطح تبعا لظروف تشغيل المضخه.

ولقد استخدم فى البداية خليط من الرمال الكوارتزية مع الماء بنسبة تركيز حجمية مقدارها ٣٠ ٪ للجسيمات الصلبة، ثم اتبع بعد ذلك باستخدام خليط من خبث الافران مع الماء بنفس نسبة التركيز، ووجد ان تاثير متغيرات كنوع المواد الصلبة ومعدل التدفق واضحا على بلى النحات لمعدن الريشة.

ان فوائد تلك الطريقة تنبع من بساطتها بالاضافة الى امكانية تصنيف البلى بنتائج مقبوله.

ABSTRACT :

A test method has been developed to rank the erosive wear of the vanes of a centrifugal-model-dredge-pump. The test allows to distinguish between leading edge erosive wear and sliding erosive wear of the vanes using specially designed moulds for the leading edge. The centrifugal model-dredge-pump with a dismountable impeller enables to measure the wear of the vanes individually as well at the leading edge as on the surface with respect to the working point of the pump .

At the beginning a solid-liquid mixture of quartz sand and water with a solid concentration of 30 % by volume was used. It was followed by a mixture of furnace slag and water with the same concentration. The effect of variables on the erosive wear rate, such as type of solid material and flow rate, can be correlated for the material weight loss of the vane.

Advantages of this method are the simplicity and the possibility of wear ranking, with acceptable results.

1. INTRODUCTION :

Erosion is inevitable in all slurry pumps and pipelines. Despite its importance, the mechanisms by which it occurs are not well understood. A primary obstacle to systematic studies is that the erosion is usually a slow process. This means that long-term experiments are required, making research very expensive. Furthermore, differences in experimental conditions have led to disagreement concerning the role of some of the important variables.

Wear rates are usually calculated as the loss in thickness, volume , or weight per unit time [1]&[2]. These absolute rates, which are commonly used in pump testing, can be easily converted to specific wear rates such as wall thickness lost per unit solids throughput [3]. Various rates have been used in the literature and care must be taken, when comparing these wear rates, that the units are the same. Relative wear rates, or the wear compared with that of reference material, may be determined by simultaneous testing of different materials but these are not common in the literature [4].

The ultimate engineering goal is to predict wear rates and to minimize erosion costs by selecting the proper material and by specifying suitable process variables. Before these goals can be achieved, the mechanisms by which wear occurs must be identified and somehow correlated with actual wear rates.

2. OUTLOOK OF THE PROBLEM :

In order to rank the erosive wear caused in impeller vanes, it is necessary to use a method which can allow the systematic evaluation of the different wears associated with slurry pumps. For example to distinguish between leading edge wear and sliding wear of the vane surface.

3. EXPERIMENTAL ARRANGEMENT :

3.1. The Leading Edge Moulds :

For the sake of distinguishing between wear caused by the sliding motion of the solids over vanes and the wear caused by the impact of stream jets at the leading edge. A specially designed mould has been manufactured for the leading edge. It consists of two vertical cuboids welded on a C-shaped beam base. Each cuboid has a slot in one side, which exactly fits the thickness of the leading edge for each vane. Special plastic material is poured inside the mould which contains the leading edge of each of the tested vanes separately.

After a certain time the plastic material solidified and the vanes were removed leaving a hollow space as shown in Figure (1). The hollow space represents the initial shape of the leading edge before experimental test. The vanes were mounted on the impeller for the experimental test after that, as shown in Figure (2). The measurements of the wear of the leading edge is taken by inserting the vanes, which were dismounted after each experimental test, into the moulds again, sealed against leakage from both sides. Water is injected by a syringe with a hypodermic needle between the leading edge and the plastic material as shown in Figure (3).

The value of the injected water to the nearest milli-liter (ml), times the vane density represent the leading edge wear due to the impact of stream jet. Weighing the vanes also after each run gives an indication about the total wear loss, i.e. due to both impact wear and sliding wear.

The difference between the two weights gives the approximate value of the loss of weight due to the sliding motion of solids over the vanes. The measured quantities of the total wear loss in grams (g) and the leading edge wear loss in milli-liter (ml) for the tested vanes using two types of solid materials are shown in Table (1) under different operating conditions.

3.2. The Solid Materials Properties :

The tests were performed using two slurry mixtures. It was necessary to select the solid materials as well suitable with respect to the transportation as wear, and which were available of constant quality, sufficient quantities and low cost. It was decided to use quartz sand of 1 mm mean diameter and furnace slag of particles diameter between o.1 to 3.5 mm, as before [5]. The results of the sieve analysis are shown in Figure (4).

3.3. The Test Loop :

The principal construction of the experimental test loop is shown in Figure (5). As can be seen from the drawing the loop acts as a closed circuit. By this means the amount of throughput is circulated through the loop is very well defined. At the pressure flange of the pump a vertical pipe section is installed fitted with a pressure tapping. The upper horizontal pipeline is used to determine pressure drop. Therefore two sets of tapping were mounted.

Following the upper horizontal pipeline on the small vertical section an inductive flow meter is installed. Depending on the targets of the experiments the lower horizontal pipe can also be provided with pressure tappings to determine the pressure drop in this part. This is especially advantageous when pressure gradients of two different types of pipes have to be compared. At the lower horizontal pipeline and before reaching the pump a last tapping is arranged to measure the suction pressure of the pump.

The measuring devices and their abilities and arrangement have already been described [6]. The driving moment of the motor is measured by the reacting momentum of the stator by means of force transducer. The deformation of the sensing element is measured by strain gauges. The sensing elements are of different construction, one is of a tube-type, the other a cantilever beam. For this type of application the force transducer should be rather rigid, because of the peaks that might be induced by short time blockages in the pump.

To measure the rotational speed a magnetic pick-up is used. It consists of a cylindrical permanent magnet surrounded by a coil and a hub. The face of the device is placed with a small gap against the circumference of a toothed wheel of steel or a disc with intersections. The passing teeth causes changes in the magnetic circuit and an electrical impulse is induced.

The signals of the mentioned instruments represent the measures of the mechanical input into the system. On the other hand the output has to be measured as well. This is reached by measuring three different parameters : the volume flow rate, the density and the differential pressure generated by the pump.

Finally pressure and differential pressure measurements must be mentioned. In all cases differential pressure transducers are used. All are based on the same sensing system but of different sensitivity. In this test loop the displacement of a membrane caused by the pressure difference on its faces is sensed by non-contacting displacement transducers. These components sense the changes of inductivity or impedance due to the motion of the membrane. These transducers are of high resolution and stability, but their natural frequency is low and the measuring volume is high. Therefore they suit for quasi stationary measurements very well, but should not be incorporated in dynamic. Additionally it should be mentioned, that it is of principle advantage to prefer differential pressure transducers to gauges in all cases, where a difference of pressure has to be determined.

Because of the considerable numbers of different unknown quantities which are to be picked up for every measuring point, only an electronic data acquisition could match all demands.

4. SOME RESULTS AND DISCUSSION :

Table (1) summarize some results obtained during the different operating conditions using the two types of solid material. The table shows the total weight loss in grams (g) and the injected water to the moulds in milli-liter (ml). Taking into consideration that the vanes produced from mild steel (St 37), the weight loss of the leading edge can be calculated. Hence the evaluation of the surface weight loss can be done.

There were noticeable differences in erosion wear between sliding wear and leading edge wear, as shown in Figures (6) & (7). The first wear exhibits a high erosion rate compared to the second. This may be attributed to the sliding-abrasion mode of wear which typically involves a bed of contact-load particles moving tangential along the vane surface. In this abrasion wear the erosion rate depends on the properties of the solid material and the wear surfaces, the normal stress and the relative velocity.

The second type of wear is the solid material-impact mode, which is caused by particle impact where individual particles of the solid material strike the leading edge.

5.PRACTICAL IMPLICATION OF THE TEST RESULTS :

The test results may be used for the prediction of wear and ranking it for the vanes of slurry pumps. This ranking is required for predicting the pre-dominant wear. In particular they may be helpful in pre-project calculations of a dredging job, providing that the types of solid materials types are known and the initial hydraulic conditions.

Also the results may be helpful in planning the operational tasks during a dredging job as related to maintenance, repair, logistics, etc.

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REFERENCES :

[1] Wiedenroth, W. , (1984), " Wear Tests Executed with a 125 mm I.D. loop and Model Dredge Pump ", Hydrotransport 9, pp.317-330.

[2] Wiedenroth, W. , (1988), " Wear of Solids-Handling Centrifugal Pump Impellers ", Hydrotransport 11, pp.507-552 .

[3] Brown, N. P. & Heywood N. I. , (1991), " Slurry Handling Design of Solid-Liquid Systems ", Elsevier Applied Science, London, pp. 399-413 .

[4] Truscott, G. F. , (1975), " A Literature Survey on Wear on Pipelines ", Publication TN 1295, BHRA Fluid Engineering, Cranfield, UK.

[5] El-Sawaf, I. & Wiedenroth, W. , (1993), " New Results on the Comparative Study between Wear Caused in A Centrifugal Slurry Pump and Slurry Abrasion Tests ", Hydrotransport 12, Brugge, Belgium, pp.211-221 .

[6] El-Sawaf, I. & Wiedenroth, W. , (1993), " Experimental Study on Wear of the Vanes of A Model-Dredge-Pump-Impeller ", Hydromechanisation 8, Magdeburg, Germany.

Table (1) Weight loss of the impeller vanes using two different solid materials & the injected water in the leading edge moulds

Solid material : Quartz sand

blade no.	operating condition / designation	A	B	C
	throughput m^3	874.80	436.80	436.50
	flow rate l/s	81	56	97
	duration min	180	130	75
S1	vane weight (initial= 1346.1 g)	1286.4	1249.3	1220.8
	i.injected water 3 ml	4.00	4.8	5.4
S2	vane weight (initial=1382.0 g)	1320.6	1286.2	1255.6
	i.injected water 2.5 ml	3.54	4.3	4.90

Solid material : Furnace slag

blade no.	operating conditon / designation	A	B	C
	throughput m^3	523.80	437.40	302.40
	flow rate l/s	97	81	56
	duration min	90	90	90
III	vane weight (initial=1400 g)	1390	1384.8	1380.7
	i.injected water .62 ml	0.9	1.18	1.4
IV	vane weight (initial=1427.3 g)	1415.4	1408.5	1404.7
	i.injected water .45 ml	1.05	1.18	1.4

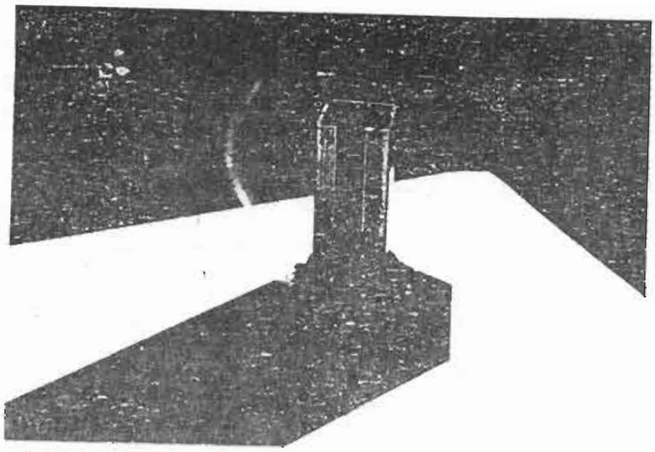

Figure (1) The hollow space of the specially designed mould

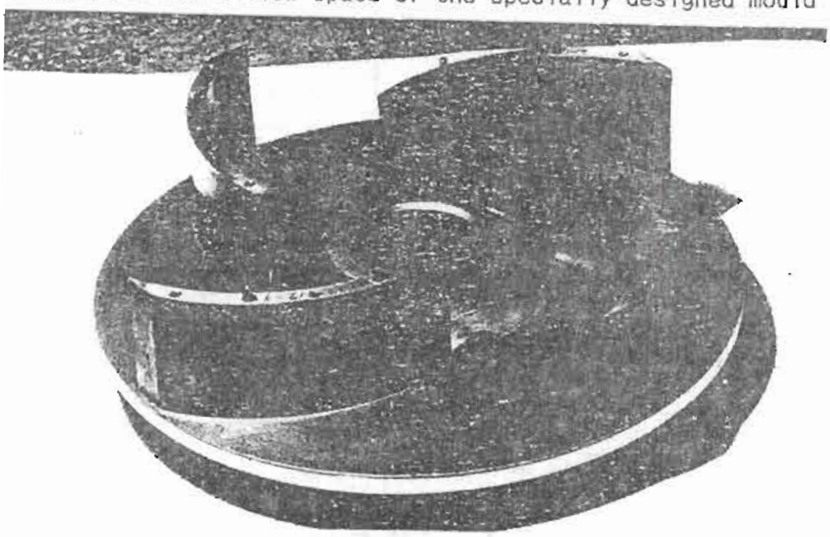

Figure (2) Dismountable impeller with four vanes and without the suction side disc

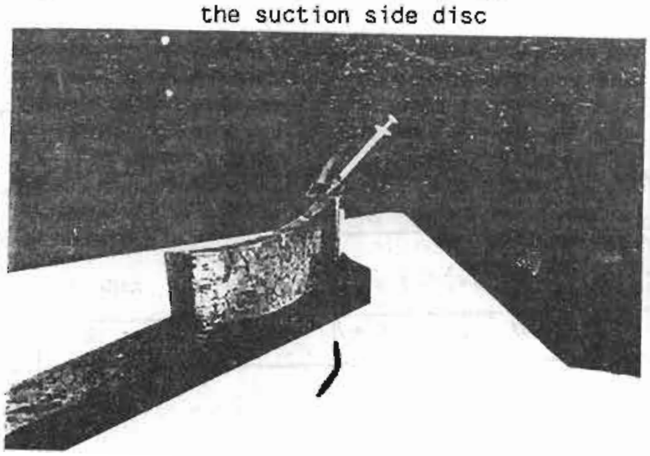

Figure (3) Injection of water between the vane leading edge and the plastic material of the mould

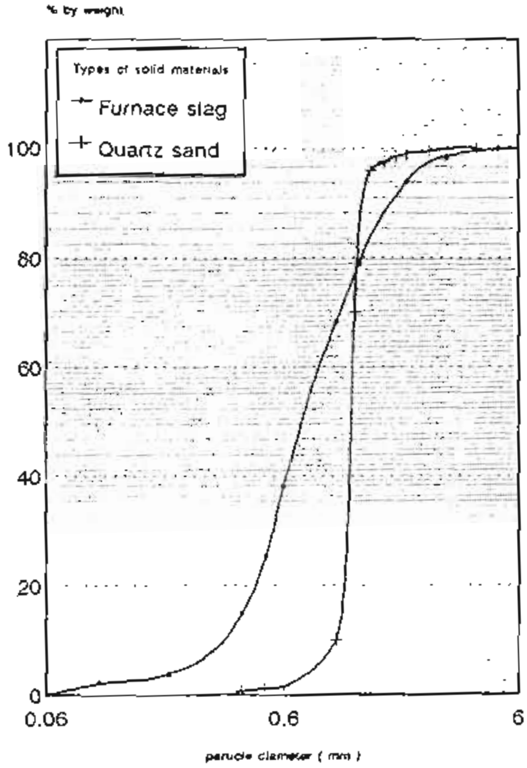

Figure (4) Results of sieve analysis of the two different solid material types

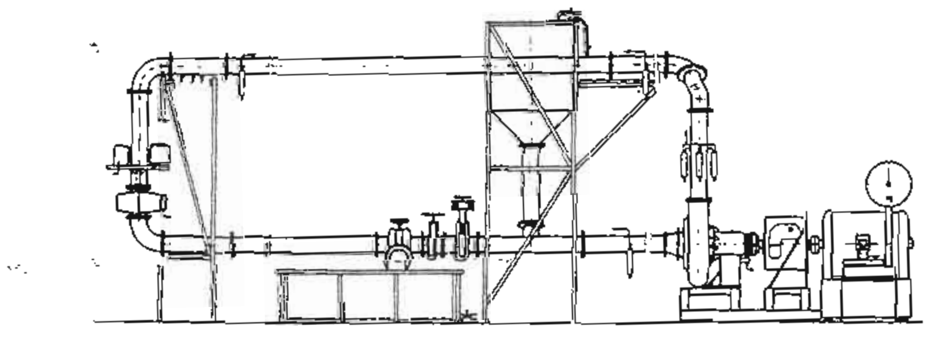

Figure (5) The experimental 125 mm I.D. test loop

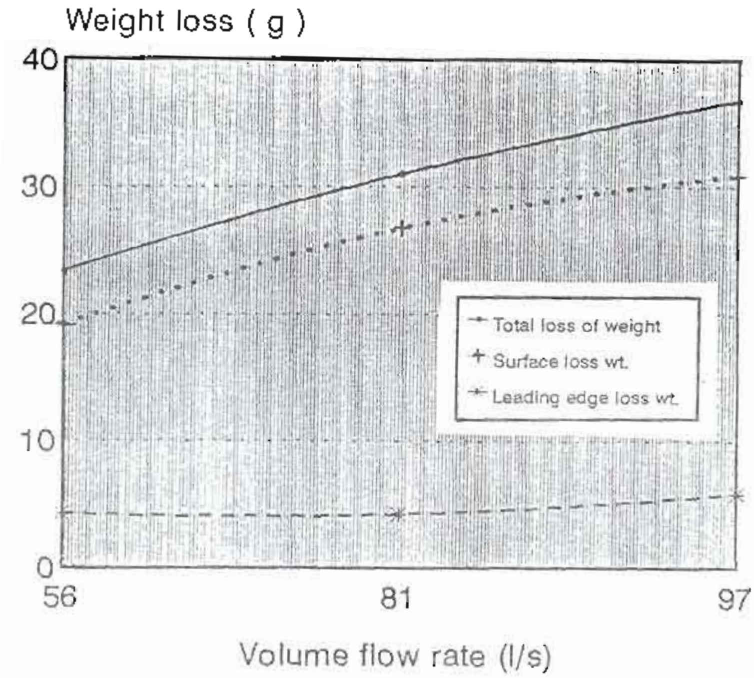

Figure (6) The effect of quartz sand on the impeller vane for both leading edge and surface wear losses

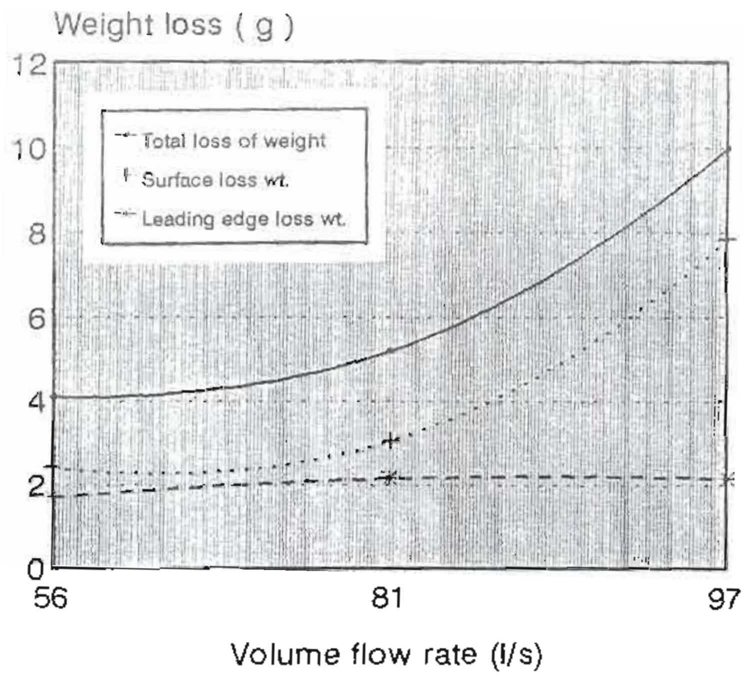

Figure (7) The effect of furnace slag on the impeller vane for both leading edge and surface wear losses